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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
09/820,694	03/30/2001	Helen H. Zhu	015290-502	7374

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Peter K. Skiff
BURNS, DOANE, SWECKER & MATHIS, L.L.P.
P.O. Box 1404
Alexandria, VA 22313-1404

EXAMINER	
MALDONADO, JULIO J	
ART UNIT	**PAPER NUMBER**
2823	

DATE MAILED: 11/20/2003

Please find below and/or attached an Office communication concerning this application or proceeding.

Office Action Summary	Application No.	Applicant(s)	
	09/820,694	ZHU ET AL.	
	Examiner	Art Unit	
	Julio J. Maldonado	2823	

-- The MAILING DATE of this communication appears on th cover sheet with the correspondenc address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133).
- Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *7/24/2003*.

2a)☒ This action is **FINAL**. 2b)☐ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *1, 2, 4-7, 9-17 and 19-23* is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *1,2,4-7,9-17 and 19-23* is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. §§ 119 and 120

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

13)☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. § 119(e) (to a provisional application) since a specific reference was included in the first sentence of the specification or in an Application Data Sheet. 37 CFR 1.78.

a) ☐ The translation of the foreign language provisional application has been received.

14)☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. §§ 120 and/or 121 since a specific reference was included in the first sentence of the specification or in an Application Data Sheet. 37 CFR 1.78.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☐ Information Disclosure Statement(s) (PTO-1449) Paper No(s) _____ .
4) ☐ Interview Summary (PTO-413) Paper No(s). _____ .
5) ☐ Notice of Informal Patent Application (PTO-152)
6) ☐ Other: .

DETAILED ACTION

1. Applicant's cancellation of claims 3, 8 and 18 is acknowledged.

2. Claims 1, 2, 4-7, 9-17 and 19-23 are pending in this application.

Response to Arguments

3. Applicant's arguments, see page 9, filed 07/24/2003, with respect to the rejection(s)of claim(s) 1-23 under 35 USC §103(a) have been fully considered and are persuasive. Therefore, the rejection has been withdrawn. However, upon further consideration, a new ground(s) of rejection is made in view of Brooks et al. (U.S. 5,786,276) and Kim et al. (U.S. 6,362,109 B1).

Claim Rejections - 35 USC § 103

4. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

5. Claim 1 is rejected under 35 U.S.C. 103(a) as being unpatentable over Brooks et al. (U.S. 5,786,276) in view of Kim et al. (U.S. 6,362,109 B1).

In reference to claim 1, Brooks et al. (Fig.1) in a related method to etch silicon nitride teach introducing a semiconductor substrate into a plasma etching reactor, the semiconductor substrate having a layer of silicon nitride and the layer of silicon nitride having an underlying and/or overlying dielectric layer; supplying etching gas to the plasma etching reactor and energizing the etching gas into a plasma state, the etching gas including CH_3F and at least one oxygen reactant supplied to the plasma etching

reactor at a flow rate ratio of oxygen reactant to CH_3F within the range of 0.65 to 1.5; and etching exposed portions of the silicon nitride layer with the plasma so as to etch openings in the silicon nitride layer with the plasma while providing an etch rate selectivity of the etching rate of the silicon nitride layer to the etching rate of the dielectric layer of at least about 50 (column 4, line 11 – column 10, line 45).

Brooks et al. fail to expressly teach the etch rate selectivity of the etching rate of the silicon nitride layer to the etching rate of the dielectric layer of at least about 10. However, in the case where the claimed ranges "overlap or lie inside ranges disclosed by the prior art" a prima facie case of obviousness exists. See MPEP 2144.05. Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to use the above-mentioned etch selectivity to arrive at the claimed invention.

Brooks et al. fail to expressly teach etching openings using a medium density plasma etching reactor. However, Kim et al. (Figs.1-3) in a related method to form a high-aspect ratio hole teach etching silicon nitride and silicon oxide in a medium density plasma reactor (40) (column 4, line 43 – column 6, line 26). Alternatively, Kim et al. teach performing said etching process on a high density plasma etching reactor as obtaining equivalent results to the medium density plasma reactor (column 7, lines 20 – 23). Therefore, it would have been obvious to one of ordinary skill in the art at the time of the invention was made to etch the silicon oxide layer and the silicon nitride layer as taught by Kim et al. in the plasma etching process of Brooks et al. because this would

allow the formation of high-aspect ratio interconnects and high selectivity over other layers formed on the substrate (column 4, lines 11 – 30).

In reference to claim 2, the combined teachings of Brooks et al. and Kim et al. teach wherein the dielectric layer comprises a doped or undoped silicon oxide film (Brooks et al., column 5,lines 42 – 56 and Kim et al., column 1, line 36 – column 2, line 24).

In reference to claim 4, the combined teachings of Brooks et al. and Kim et al. teach wherein the etching gas is nitrogen-free (Brooks et al., column 7, lines 19 – 23).

In reference to claim 5, the combined teachings of Brooks et al. and Kim et al. teach wherein etching gas consists essentially of CH_3F, oxygen and optionally Ar (Brooks et al., column 7, lines 19 – 23).

In reference to claim 6, the combined teachings of Brooks et al. and Kim et al. teach wherein the silicon nitride layer overlies or underlies an organic low-k dielectric material (Kim et al., column 1, line 36 – column 2, line 24).

In reference to claim 7, the combined teachings of Brooks et al. and Kim et al. substantially teach all aspects of the invention but fail to teach wherein the openings are 0.25 micron or smaller sized openings and/or wide open trenches. Notwithstanding, it would have been an obvious matter of design choice bounded by well known manufacturing constraints and ascertainable by routine experimentation and optimization to choose these particular dimensions because applicant has not disclosed that the dimensions are for a particular unobvious purpose, produce an unexpected result, or are otherwise critical, and it appears prima facie that the process would

possess utility using another dimension. Indeed, it has been held that mere dimensional limitations are prima facie obvious absent a disclosure that the limitations are for a particular unobvious purpose, produce an unexpected result, or are otherwise critical. See, for example, In re Rose, 220 F.2d 459, 105 USPQ 237 (CCPA 1955); In re Rinehart, 531 F.2d 1048, 189 USPQ 143 (CCPA 1976); Gardner v. TEC Systems, Inc., 725 F.2d 1338, 220 USPQ 777 (Fed. Cir. 1984), cert. denied, 469 U.S. 830, 225 USPQ 232 (1984); In re Dailey, 357 F.2d 669, 149 USPQ 47 (CCPA 1966).

In reference to claim 9, the combined teachings of Brooks et al. and Kim et al. teach wherein the etching gas includes a carrier gas selected from the group consisting of Ar, He, Ne, Kr, Xe or mixtures thereof (Brooks et al., column 7, lines 19 – 23).

In reference to claim 11, the combined teachings of Brooks et al. and Kim et al. teach wherein the etching gas is nitrogen-free and the flow rate ratio of the oxygen reactant to fluorocarbon reactant is 1 or less (Brooks et al., column 10, lines 26 – 45).

In reference to claims 12 and 19-20, the combined teachings of Brooks et al. and Kim et al. teach wherein the fluorocarbon reactant is supplied to the plasma reactor at a flow rate of 42 to 132 sccm and the oxygen reactant is supplied to the plasma reactor at a flow rate of 112 to 192.5 sccm (Brooks et al., column 10, lines 26 – 45); wherein the plasma reactor is at a pressure of 400 to 500 mTorr during the etching step (Brooks et al. column 9, line 13); and wherein the semiconductor substrate comprises a silicon wafer supported on a bottom electrode and the bottom electrode is maintained at a temperature of 20 to 100°C (Brooks et al., column 4, lines 31 – 36 and Kim et al., column 3, lines 43 – 50). The combined teachings of Brooks et al. and Kim et al. fail to

teach wherein the fluorocarbon reactant is supplied to the plasma reactor at a flow rate of 5 to 200 sccm and the oxygen reactant is supplied to the plasma reactor at a flow rate of 5 to 200 sccm; wherein the plasma reactor is at a pressure of 5 to 1,000 mTorr during the etching step; and wherein the bottom electrode is maintained at a temperature of 20 to 50°C. However, in the case where the claimed ranges "overlap or lie inside ranges disclosed by the prior art" a prima facie case of obviousness exists. See MPEP 2144.05. Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to use the above-mentioned flow range to arrive at the claimed invention.

In reference to claim 13, the combined teachings of Brooks et al. and Kim et al. teach applying an RF bias to the semiconductor substrate during the etching step (Kim et al., column 3, lines 51 – 63).

In reference to claim 14, the combined teachings of Brooks et al. and Kim et al. teach wherein the silicon nitride layer overlies an electrically conductive or semiconductive layer comprising a metal-containing layer selected from the group consisting of doped and undoped polycrystalline or single crystal silicon (Kim et al., column 1, line 66 – column 2, line 8).

In reference to claim 15, the combined teachings of Brooks et al. and Kim et al. teach wherein the etching step is carried out as part of a process of manufacturing a damascene structure (Kim et al., Figs.2).

In reference to claim 16, the combined teachings of Brooks et al. and Kim et al. teach forming a photoresist layer as a masking layer, patterning the photoresist layer to form a plurality of the openings and the etching step forms via or contact openings in the silicon nitride layer (Kim et al., column 2, lines 25 – 64).

In reference to claim 22, the combined teachings of Brooks et al. and Kim et al. substantially teach all aspects of the invention but fail to teach wherein the fluorocarbon reactant is supplied to the plasma reactor at a flow rate of 20 to 40 sccm and the oxygen reactant is supplied to the plasma reactor at a flow rate of 20 to 40 sccm. However, the selection of the claimed flow ranges is obvious because it is a matter of determining optimum process condition by routine experimentation with a limited number of species. Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to use the claimed ranges to arrive at the claimed invention.

6. Claims 10 and 23 are rejected under 35 U.S.C. 103(a) as being unpatentable over Brooks et al. (U.S. 5,786,276) in view of Kim et al. (U.S. 6,362,109 B1) as applied to claims 1 above, and further in view of Okumura et al. (U.S. 6,355,573 B1).

The combined teachings of Brooks et al. and Kim et al. substantially teach all aspects of the invention but fail to teach wherein the plasma reactor comprises a dual frequency parallel plate plasma reactor having a showerhead electrode and a bottom electrode on which the substrate is supported, the bottom electrode being supplied RF energy at two different frequencies or the showerhead electrode being supplied RF energy at a first frequency and the bottom electrode being supplied RF energy at a

second frequency which is greater than the first frequency. However, Okumura et al. (Figs.1, 2 and 10) in a related method to perform plasma etching on dielectric layers teach a plasma reactor comprising a dual frequency parallel plate plasma reactor having a showerhead electrode (5) and a bottom electrode (6) on which a substrate (7) is supported, the showerhead electrode being supplied RF energy at a first frequency and the bottom electrode being supplied RF energy at a second frequency (column 1, line 30 – column 7, line 45). Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to combine the teachings of Brooks et al., Kim et al., and Okumura et al. to enable performing the etching process of Brooks et al. and Kim et al. in the plasma apparatus of Okumura et al.

The combined teachings of Brooks et al., Kim et al. and Okumura et al. fail to teach wherein the second frequency is greater than the first frequency. However, the selection of the first and second frequency is obvious because it is a matter of determining optimum process condition by routine experimentation with a limited number of species. Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to enable using the frequencies as disclosed to arrive at the claimed invention.

In reference to claim 23, the combined teachings of Brooks et al., Kim et al. and Okumura et al. teach wherein the reactor comprises a capacitively coupled plasma reactor (Okumura et al., column 2, lines 13 – 21).

7. Claim 17 is rejected under 35 U.S.C. 103(a) as being unpatentable over Brooks et al. (U.S. 5,786,276) in view of Kim et al. (U.S. 6,362,109 B1) as applied to claims 1 above, and further in view of the Applicants Admitted Prior Art.

The combined teachings of Brooks et al. and Kim et al. substantially teach all aspects of the invention but fail to teach wherein the silicon nitride layer is between an overlying dielectric layer and an underlying copper layer, the copper layer being exposed to the plasma in the openings during the etching step. However, the prior art teaches a method to form a damascene structure including forming a silicon nitride layer between an overlying dielectric layer and an underlying copper layer, the copper layer being exposed to a plasma in the openings during an etching step (instant page 1, line 5 – page 2, line 20). Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to combine the teachings of Brooks et al. and Kim et al. with the teachings of the prior art to enable applying the nitride selective etching process as taught by Brooks et al. and Kim et al. in the damascene structure of the prior art.

Response to Arguments

8. Applicant's arguments with respect to claims 1, 2, 4-7, 9-17 and 19-23 have been considered but are moot in view of the new ground(s) of rejection.

Conclusion

9. Applicant's amendment necessitated the new ground(s) of rejection presented in this Office action. Accordingly, **THIS ACTION IS MADE FINAL**. See MPEP

§ 706.07(a). Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is filed within TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after the end of the THREE-MONTH shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the date of this final action.

10. Papers related to this application may be submitted directly to Art Unit 2823 by facsimile transmission. Papers should be faxed to Art Unit 2823 via the Art Unit 2823 Fax Center located in Crystal Plaza 4, room 3C23. The faxing of such papers must conform to the notice published in the Official Gazette, 1096 OG 30 (15 November 1989). The Art Unit 2823 Fax Center number is **(703) 305-3432**. The Art Unit 2823 Fax Center is to be used only for papers related to Art Unit 2823 applications.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to **Julio J. Maldonado** at **(703) 306-0098** and between the hours of 8:00 AM to 4:00 PM (Eastern Standard Time) Monday through Friday or by e-mail via julio.maldonado@uspto.gov. If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Olik Chaudhuri, can be reached on (703) 306-2794.

Any inquiry of a general nature or relating to the status of this application should be directed to the **Group 2800 Receptionist** at **(703) 308-0956**.

JMR
11/10/03

George Fourson
Primary Examiner